

Appl. No. 10/074,941

Response to Office Action dated July 21, 2004

**LISTING OF THE CLAIMS**

Claims 1-56 are pending. No claims are amended, added, or canceled.

The following listing of claims replaces all prior versions and listings of claims in the application.

1. (Original) A method for image retrieval using a statistical bigram correlation model, the method comprising:

receiving a plurality of images responsive to multiple search sessions;  
determining whether the images are semantically relevant images via relevance feedback; and

estimating a respective semantic correlation between each of at least one pair of the images with a respective bigram frequency, each respective bigram frequency being based on multiple search sessions in which each image of the pair is indicated to be a semantically relevant image.

2. (Original) A method as recited in claim 1, further comprising:

assigning a respective ranking score to each of the images based at least in part on the respective semantic correlation corresponding to the image; and  
displaying only those images with a highest range of ranking scores.

3. (Original) A method as recited in claim 1, further comprising, responsive to a search session, dynamically updating the respective bigram frequency corresponding to two of the images.

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1 4. (Original) A method as recited in claim 1, wherein the respective semantic  
2 correlation is: (a) a positive correlation between two semantically relevant images;  
3 (b) a negative correlation between a semantically relevant image and a  
4 semantically irrelevant image; and (c) no correlation otherwise.

5  
6 5. (Original) A method as recited in claim 1:

7 wherein the respective semantic correlation is performed offline or online  
8 to calculate unigram and bigram frequencies from relevance feedback information,  
9 the unigram frequency being based on relevance feedback to a session of the  
10 multiple search sessions, the unigram frequency indicating that each respective  
11 image of the images is either semantically relevant to the session, semantically  
12 less relevant to the session, or a non-feedback image with respect to the session;  
13 and

14 wherein each respective bigram frequency is based on a pair of unigram  
15 frequencies.

16  
17 6. (Original) A method as recited in claim 1, wherein estimating the respective  
18 semantic correlation further comprises:

19 associating a respective unigram frequency with each of the images, the  
20 unigram frequency indicating that each respective image of the images is either  
21 semantically relevant, semantically less relevant, or a non-feedback image, the  
22 unigram frequency being based on relevance feedback to a session of the multiple  
23 search sessions; and

24 wherein each respective bigram frequency is based on a pair of unigram  
25 frequencies.

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7. (Original) A method as recited in claim 1, wherein estimating the respective semantic correlation further comprises:

associating a respective unigram frequency with each of the images, the unigram frequency indicating that each respective image of the images is either semantically relevant, semantically less relevant, or a non-feedback image, the unigram frequency being based on relevance feedback to a session of the multiple search sessions;

determining a maximum frequency from a maximum value of the bigram and unigram frequencies; and

wherein the respective semantic correlation is further based on the maximum frequency.

8. (Original) A method as recited in claim 1, further comprising identifying, for each image obtained responsive to one or more search sessions of the multiple search sessions, a respective semantic support based on a similarity measure and/or the respective semantic correlation, the similarity measure corresponding to a similarity of a respective feature vector of the image and a search query corresponding to the session.

9. (Original) A method as recited in claim 1, further comprising:

identifying, for each image obtained responsive to one or more search sessions of the multiple search sessions, a respective semantic support based on a similarity measure and/or the respective semantic correlation, the similarity

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1 measure corresponding to a similarity of a respective feature vector of the image  
2 and a search query corresponding to the session;

3 assigning a respective ranking score to each of the images based upon the  
4 respective similarity measure, the respective semantic support, and a semantic  
5 weight; and

6 displaying only those images with a highest range of respective ranking  
7 scores.

8  
9 10. (Original) A method as recited in claim 1, wherein estimating the  
10 respective semantic correlation is determined as follows:

- 11 •  $0 \leq R(I, J) \leq 1$  [if is true in all cases]
- 12 •  $R(I, J) = R(J, I)$ ; [if is true in all cases]
- 13 • if  $I = J$  and  $U(I) \leq 0$ :  $R(I, J) = 0$ ;
- 14 • if  $I \neq J$  and  $B(I, J) \leq 0$ :  $R(I, J) = 0$ ;
- 15 • if  $I = J$  and  $U(I) > 0$ :  $R(I, J) = U(I)/T$ ; or
- 16 • if  $I \neq J$  and  $B(I, J) > 0$ :  $R(I, J) = B(I, J)/T$ ;

17 wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency,  $U(I)$  is the  
18 unigram frequency of image  $I$ ,  $T$  is the maximum frequency,  $R(I, J)$  is the  
19 correlation between image  $I$  and  $J$ .

20  
21 11. (Original) A method as recited in claim 1, wherein each respective bigram  
22 frequency is based on a pair of unigram frequencies, and wherein the method  
23 further comprises performing the respective semantic correlation offline by:

- 24 (a) initializing all unigram and bigram frequencies to zero;
- 25 (b) clustering search sessions with a same query into groups;

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(c) calculating unigram counts within a group;  
(d) updating unigram frequencies ;  
(e) updating bigram frequencies;  
(f) repeating operations (c), (d), and (f) for all session groups;  
(g) setting all negative unigram and bigram frequencies to zero; and  
(h) calculating each respective semantic correlation based on results of (a) through (f).

12. (Original) A method as recited in claim 1, wherein each respective bigram frequency is based on a pair of unigram frequencies, wherein  $C(I)$  is a unigram count of image  $I$ , and wherein the method further comprises performing the respective semantic correlation offline by:

(a) initializing  $C(I)$  to zero (0);

(b) iteratively updating  $C(I)$  for every session in a group such that:

$C(I) = C(I) + 1$ , if image  $I$  is labeled as relevant in a session;

$C(I) = C(I) - 1$ , if image  $I$  is labeled as irrelevant in a session;

and

$C(I)$  is unchanged otherwise.

(c) repeating (b) for every image of the images;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + \min\{C(I), C(J)\}$ , if  $C(I) > 0, C(J) > 0$ ,

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$$B(I, J) = B(I, J) - \min\{C(I), -C(J)\}, \text{ if } C(I) > 0, C(J) < 0,$$

$$B(I, J) = B(I, J) - \min\{-C(I), C(J)\}, \text{ if } C(I) < 0, C(J) > 0, \text{ and}$$

$$B(I, J) = B(I, J), \text{ otherwise; and}$$

wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency, and  $U(I)$  is the unigram frequency of image  $I$ .

13. (Original) A method as recited in claim 1, wherein each respective bigram frequency is based on a pair of unigram frequencies, and wherein the method further comprises performing the respective semantic correlation online by:

- (a) calculating unigram counts in a particular search session;
- (b) updating unigram frequencies;
- (c) updating bigram frequencies; and
- (d) updating each respective semantic correlation between each of the images based on results of (a) through (c).

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14. (Original) A method as recited in claim 1, wherein each respective bigram frequency is based on a pair of unigram frequencies, wherein  $C(I)$  is a unigram count of image  $I$ , wherein  $U(I)$  is a unigram frequency of image  $I$ , wherein  $B(I, J)$  is a bigram frequency of image  $I$  and  $J$ , wherein a session group comprises a single search session, and wherein the method further comprises performing the respective semantic correlation online by:

(a) responsive to determining that there is a user log, updating calculating each respective unigram and bigram frequency according to data in the user log;

(b) responsive to determining that there is not a user log, initializing each  $C(I)$  and  $B(I)$  to zero (0);

(c) iteratively updating  $C(I)$  for the single search session such that:

$C(I) = 1$ , if image  $I$  is labeled as relevant;

$C(I) = -1$ , if image  $I$  is labeled as irrelevant; and

$C(I) = 0$ , if  $C(I)$  is a non-feedback image;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + 1$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) < 0, C(J) > 0$ , or

$B(I, J) = B(I, J)$ , otherwise; and

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wherein  $I, J$  are two images, and  $B(I, J)$  is their bigram frequency.

15. (Original) A computer-readable medium for image retrieval using a statistical bigram correlation model, the computer-readable medium comprising computer-executable instructions for:

receiving a plurality of images responsive to multiple search sessions;  
determining whether the images are semantically relevant images via relevance feedback; and

estimating a respective semantic correlation between each of at least one pair of the images with a respective bigram frequency, each respective bigram frequency representing a probability of whether two of the images are semantically related to one-another based on a co-occurrence frequency that each image of the two images was relevant in a previous query/feedback session.

16. (Original) A computer-readable medium as recited in claim 15, further comprising instructions for:

assigning a respective ranking score to each of the images based at least in part on the respective semantic correlation corresponding to the image; and  
displaying only those images with a highest range of ranking scores.

17. (Original) A computer-readable medium as recited in claim 15, further comprising instructions for, responsive to a search session, dynamically updating the respective bigram frequency corresponding to two of the images.



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18. (Original) A computer-readable medium as recited in claim 15, wherein the respective semantic correlation is: (a) a positive correlation between two semantically relevant images; (b) a negative correlation between a semantically relevant image and a semantically irrelevant image; and (c) no correlation otherwise.

19. (Original) A computer-readable medium as recited in claim 15:

wherein the respective semantic correlation is performed offline or online to calculate unigram and bigram frequencies from relevance feedback information, the unigram frequency being based on relevance feedback to a session of the multiple search sessions, the unigram frequency indicating that each respective image of the images is either semantically relevant to the session, semantically less relevant to the session, or a non-feedback image with respect to the session; and

wherein each respective bigram frequency is based on a pair of unigram frequencies.

20. (Original) A computer-readable medium as recited in claim 15, wherein estimating the respective semantic correlation further comprises instructions for:

associating a respective unigram frequency with each of the images, the unigram frequency indicating that each respective image of the images is either semantically relevant, semantically less relevant, or a non-feedback image, the unigram frequency being based on relevance feedback to a session of the multiple search sessions; and

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1 wherein each respective bigram frequency is based on a pair of unigram  
2 frequencies.

3  
4 **21.** (Original) A computer-readable medium as recited in claim 15, wherein  
5 estimating the respective semantic correlation further comprises instructions for:

6 associating a respective unigram frequency with each of the images, the  
7 unigram frequency indicating that each respective image of the images is either  
8 semantically relevant, semantically less relevant, or a non-feedback image, the  
9 unigram frequency being based on relevance feedback to a session of the multiple  
10 search sessions;

11 determining a maximum frequency from a maximum value of the bigram  
12 and unigram frequencies; and

13 wherein the respective semantic correlation is further based on the  
14 maximum frequency.

15  
16 **22.** (Original) A computer-readable medium as recited in claim 15, further  
17 comprising instructions for identifying, for each image obtained responsive to one  
18 or more search sessions of the multiple search sessions, a respective semantic  
19 support based on a similarity measure and/or the respective semantic correlation,  
20 the similarity measure corresponding to a similarity of a respective feature vector  
21 of the image and a search query corresponding to the session.

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23. (Original) A computer-readable medium as recited in claim 15, further comprising instructions for:

identifying, for each image obtained responsive to one or more search sessions of the multiple search sessions, a respective semantic support based on a similarity measure and/or the respective semantic correlation, the similarity measure corresponding to a similarity of a respective feature vector of the image and a search query corresponding to the session;

assigning a respective ranking score to each of the images based upon the respective similarity measure, the respective semantic support, and a semantic weight; and

displaying only those images with a highest range of respective ranking scores.

24. (Original) A computer-readable medium as recited in claim 15, wherein estimating the respective semantic correlation is determined as follows:

- $0 \leq R(I, J) \leq 1$
- $R(I, J) = R(J, I)$ ;
- if  $I=J$  and  $U(I) \leq 0$  :  $R(I, J) = 0$  ;
- if  $I \neq J$  and  $B(I, J) \leq 0$  :  $R(I, J) = 0$  ;
- if  $I=J$  and  $U(I) > 0$  :  $R(I, J) = U(I)/T$  ; or
- if  $I \neq J$  and  $B(I, J) > 0$  :  $R(I, J) = B(I)/T$  ;

wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency,  $U(I)$  is the unigram frequency of image  $I$ ,  $T$  is the maximum frequency,  $R(I, J)$  is the correlation between image  $I$  and  $J$ .

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1 **25.** (Original) A computer-readable medium as recited in claim 15, wherein  
2 each respective bigram frequency is based on a pair of unigram frequencies, and  
3 wherein the computer-executable instructions further comprise instructions for  
4 performing the respective semantic correlation offline by:

- 5 (a) initializing all unigram and bigram frequencies to zero;
- 6 (b) clustering search sessions with a same query into groups;
- 7 (c) calculating unigram counts within a group;
- 8 (d) updating unigram frequencies ;
- 9 (e) updating bigram frequencies;
- 10 (f) repeating operations (c), (d), and (f) for all session groups;
- 11 (g) setting all negative unigram and bigram frequencies to zero; and
- 12 (h) calculating each respective semantic correlation based on results of (a)  
13 through (f).

14  
15 **26.** (Original) A computer-readable medium as recited in claim 15, wherein  
16 each respective bigram frequency is based on a pair of unigram frequencies,  
17 wherein  $C(I)$  is a unigram count of image  $I$ , and wherein the computer-executable  
18 instructions further comprise instructions for performing the respective semantic  
19 correlation offline by:

20 (a) initializing  $C(I)$  to zero (0);

21 (b) iteratively updating  $C(I)$  for every session in a group such that:

22  $C(I) = C(I) + 1$ , if image  $I$  is labeled as relevant in a session;

23  $C(I) = C(I) - 1$ , if image  $I$  is labeled as irrelevant in a session;

24 and  
25

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$C(I)$  is unchanged otherwise;

(c) repeating (b) for every image of the images;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such

that:

$B(I, J) = B(I, J) + \min\{C(I), C(J)\}$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - \min\{C(I), -C(J)\}$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - \min\{-C(I), C(J)\}$ , if  $C(I) < 0, C(J) > 0$ , and

$B(I, J) = B(I, J)$ , otherwise; and

wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency, and  $U(I)$  is the unigram frequency of image  $I$ .

27. (Original) A computer-readable medium as recited in claim 15, wherein each respective bigram frequency is based on a pair of unigram frequencies, and wherein the computer-executable instructions further comprise instructions for performing the respective semantic correlation online by:

(a) calculating unigram counts in a particular search session;

(b) updating unigram frequencies;

(c) updating bigram frequencies; and

(d) updating each respective semantic correlation between each of the images based on results of (a) through (c).

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28. (Original) A computer-readable medium as recited in claim 15, wherein each respective bigram frequency is based on a pair of unigram frequencies, wherein  $C(I)$  is a unigram count of image  $I$ , wherein  $U(I)$  is a unigram frequency of image  $I$ , wherein  $B(I, J)$  is a bigram frequency of image  $I$  and  $J$ , wherein a session group comprises a single search session, and wherein the computer-executable instructions further comprise instructions for performing the respective semantic correlation online by:

(a) responsive to determining that there is a user log, updating calculating each respective unigram and bigram frequency according to data in the user log;

(b) responsive to determining that there is not a user log, initializing each  $C(I)$  and  $B(I)$  to zero (0);

(c) iteratively updating  $C(I)$  for the single search session such that:

$C(I) = 1$ , if image  $I$  is labeled as relevant;

$C(I) = -1$ , if image  $I$  is labeled as irrelevant; and

$C(I) = 0$ , if  $C(I)$  is a non-feedback image;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + 1$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) < 0, C(J) > 0$ , or

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1  $B(I, J) = B(I, J)$ , otherwise; and

2 wherein  $I, J$  are two images, and  $B(I, J)$  is their bigram frequency.

3  
4 29. (Original) A computing device for image retrieval using a statistical bigram  
5 correlation model, the computing device comprising:

6 a processor; and

7 a memory coupled to the processor, the memory comprising computer-  
8 executable instructions that are fetched and executed by the processor for:

9 receiving a plurality of images responsive to multiple search  
10 sessions;

11 determining whether the images are semantically relevant images via  
12 relevance feedback; and

13 estimating a respective semantic correlation between each of at least  
14 one pair of the images with a respective bigram frequency, each respective bigram  
15 frequency being based on multiple search sessions in which each image of the pair  
16 is indicated to be a semantically relevant image.

17  
18 30. (Original) A computing device as recited in claim 29, further comprising  
19 instructions for:

20 assigning a respective ranking score to each of the images based at least in  
21 part on the respective semantic correlation corresponding to the image; and

22 displaying only those images with a highest range of ranking scores.  
23  
24  
25

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1 **31.** (Original) A computing device as recited in claim 29, further comprising  
2 instructions for, responsive to a search session, dynamically updating the  
3 respective bigram frequency corresponding to two of the images.

4  
5 **32.** (Original) A computing device as recited in claim 29, wherein the  
6 respective semantic correlation is: (a) a positive correlation between two  
7 semantically relevant images; (b) a negative correlation between a semantically  
8 relevant image and a semantically irrelevant image; and (c) no correlation  
9 otherwise.

10  
11 **33.** (Original) A computing device as recited in claim 29:

12 wherein the respective semantic correlation is performed offline or online  
13 to calculate unigram and bigram frequencies from relevance feedback information,  
14 the unigram frequency being based on relevance feedback to a session of the  
15 multiple search sessions, the unigram frequency indicating that each respective  
16 image of the images is either semantically relevant to the session, semantically  
17 less relevant to the session, or a non-feedback image with respect to the session;  
18 and

19 wherein each respective bigram frequency is based on a pair of unigram  
20 frequencies.

21  
22 **34.** (Original) A computing device as recited in claim 29, wherein estimating  
23 the respective semantic correlation further comprises instructions for:

24 associating a respective unigram frequency with each of the images, the  
25 unigram frequency indicating that each respective image of the images is either



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1 semantically relevant, semantically less relevant, or a non-feedback image, the  
2 unigram frequency being based on relevance feedback to a session of the multiple  
3 search sessions; and

4 wherein each respective bigram frequency is based on a pair of unigram  
5 frequencies.

6  
7 35. (Original) A computing device as recited in claim 29, wherein estimating  
8 the respective semantic correlation further comprises instructions for:

9 associating a respective unigram frequency with each of the images, the  
10 unigram frequency indicating that each respective image of the images is either  
11 semantically relevant, semantically less relevant, or a non-feedback image, the  
12 unigram frequency being based on relevance feedback to a session of the multiple  
13 search sessions;

14 determining a maximum frequency from a maximum value of the bigram  
15 and unigram frequencies; and

16 wherein the respective semantic correlation is further based on the  
17 maximum frequency.

18  
19 36. (Original) A computing device as recited in claim 29, further comprising  
20 instructions for identifying, for each image obtained responsive to one or more  
21 search sessions of the multiple search sessions, a respective semantic support  
22 based on a similarity measure and/or the respective semantic correlation, the  
23 similarity measure corresponding to a similarity of a respective feature vector of  
24 the image and a search query corresponding to the session.

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1 37. (Original) A computing device as recited in claim 29, further comprising  
2 instructions for:

3 identifying, for each image obtained responsive to one or more search  
4 sessions of the multiple search sessions, a respective semantic support based on a  
5 similarity measure and/or the respective semantic correlation, the similarity  
6 measure corresponding to a similarity of a respective feature vector of the image  
7 and a search query corresponding to the session;

8 assigning a respective ranking score to each of the images based upon the  
9 respective similarity measure, the respective semantic support, and a semantic  
10 weight; and

11 displaying only those images with a highest range of respective ranking  
12 scores.

13  
14 38. (Original) A computing device as recited in claim 29, wherein estimating  
15 the respective semantic correlation is determined as follows:

- 16 •  $0 \leq R(I, J) \leq 1$
- 17 •  $R(I, J) = R(J, I)$ ;
- 18 • if  $I=J$  and  $U(I) \leq 0$  :  $R(I, J) = 0$  ;
- 19 • if  $I \neq J$  and  $B(I, J) \leq 0$  :  $R(I, J) = 0$  ;
- 20 • if  $I=J$  and  $U(I) > 0$  :  $R(I, J) = U(I)/T$  ; or
- 21 • if  $I \neq J$  and  $B(I, J) > 0$  :  $R(I, J) = B(I)/T$  ;

22 wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency,  $U(I)$  is the  
23 unigram frequency of image  $I$ ,  $T$  is the maximum frequency,  $R(I, J)$  is the  
24 correlation between image  $I$  and  $J$ .

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1 **39.** (Original) A computing device as recited in claim 29, wherein each  
2 respective bigram frequency is based on a pair of unigram frequencies, and  
3 wherein the computer-executable instructions further comprise instructions for  
4 performing the respective semantic correlation offline by:

- 5 (a) initializing all unigram and bigram frequencies to zero;
- 6 (b) clustering search sessions with a same query into groups;
- 7 (c) calculating unigram counts within a group;
- 8 (d) updating unigram frequencies ;
- 9 (e) updating bigram frequencies;
- 10 (f) repeating operations (c), (d), and (f) for all session groups;
- 11 (g) setting all negative unigram and bigram frequencies to zero; and
- 12 (h) calculating each respective semantic correlation based on results of (a)  
13 through (f).

14  
15 **40.** (Original) A computing device as recited in claim 29, wherein each  
16 respective bigram frequency is based on a pair of unigram frequencies, wherein  
17  $C(I)$  is a unigram count of image  $I$ , and wherein the computer-executable  
18 instructions further comprise instructions for performing the respective semantic  
19 correlation offline by:

20 (a) initializing  $C(I)$  to zero (0);

21 (b) iteratively updating  $C(I)$  for every session in a group such that:

22  $C(I) = C(I) + 1$ , if image  $I$  is labeled as relevant in a session;

23  $C(I) = C(I) - 1$ , if image  $I$  is labeled as irrelevant in a session;

24 and  
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1  $C(I)$  is unchanged otherwise;

2 (c) repeating (b) for every image of the images;

3 (d) updating each respective unigram frequencies as  $U(J) = U(I) + C(I)$ ;

4 (e) updating each respective bigram frequency of an image pair such

5 that:

6  $B(I, J) = B(I, J) + \min\{C(I), C(J)\}$ , if  $C(I) > 0, C(J) > 0$ ,

7  $B(I, J) = B(I, J) - \min\{C(I), -C(J)\}$ , if  $C(I) > 0, C(J) < 0$ ,

8  $B(I, J) = B(I, J) - \min\{-C(I), C(J)\}$ , if  $C(I) < 0, C(J) > 0$ , and

9  $B(I, J) = B(I, J)$ , otherwise; and

10 wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency, and  
11  $U(I)$  is the unigram frequency of image  $I$ .

12  
13  
14  
15 41. (Original) A computing device as recited in claim 29, wherein each  
16 respective bigram frequency is based on a pair of unigram frequencies, and  
17 wherein the computer-executable instructions further comprise instructions for  
18 performing the respective semantic correlation online by:

19 (a) calculating unigram counts in a particular search session;

20 (b) updating unigram frequencies;

21 (c) updating bigram frequencies; and

22 (d) updating each respective semantic correlation between each of the  
23 images based on results of (a) through (c).

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42. (Original) A computing device as recited in claim 29, wherein each respective bigram frequency is based on a pair of unigram frequencies, wherein  $C(I)$  is a unigram count of image  $I$ , wherein  $U(I)$  is a unigram frequency of image  $I$ , wherein  $B(I, J)$  is a bigram frequency of image  $I$  and  $J$ , wherein a session group comprises a single search session, and wherein the computer-executable instructions further comprise instructions for performing the respective semantic correlation online by:

(a) responsive to determining that there is a user log, updating calculating each respective unigram and bigram frequency according to data in the user log;

(b) responsive to determining that there is not a user log, initializing each  $C(I)$  and  $B(I)$  to zero (0);

(c) iteratively updating  $C(I)$  for the single search session such that:

$C(I) = 1$ , if image  $I$  is labeled as relevant;

$C(I) = -1$ , if image  $I$  is labeled as irrelevant; and

$C(I) = 0$ , if  $C(I)$  is a non-feedback image;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + 1$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) < 0, C(J) > 0$ , or

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1  $B(I, J) = B(I, J)$ , otherwise; and

2 wherein  $I, J$  are two images, and  $B(I, J)$  is their bigram frequency.

3  
4 43. (Original) A computing device image retrieval using a statistical bigram  
5 correlation model, the computing device comprising:

6 processing means for:

7 receiving a plurality of images responsive to multiple search  
8 sessions;

9 determining whether the images are semantically relevant images via  
10 relevance feedback; and

11 estimating a respective semantic correlation between each of at least  
12 one pair of the images with a respective bigram frequency, each respective bigram  
13 frequency being based on multiple search sessions in which each image of the pair  
14 is indicated to be a semantically relevant image.

15  
16 44. (Original) A computing device as recited in claim 43, further comprising  
17 means for:

18 assigning a respective ranking score to each of the images based at least in  
19 part on the respective semantic correlation corresponding to the image; and

20 displaying only those images with a highest range of ranking scores.

21  
22 45. (Original) A computing device as recited in claim 43, further comprising  
23 means for, responsive to a search session, dynamically updating the respective  
24 bigram frequency corresponding to two of the images.

25

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1  
2 46. (Original) A computing device as recited in claim 43, wherein the  
3 respective semantic correlation is: (a) a positive correlation between two  
4 semantically relevant images; (b) a negative correlation between a semantically  
5 relevant image and a semantically irrelevant image; and (c) no correlation  
6 otherwise.

7  
8 47. (Original) A computing device as recited in claim 43:

9 wherein the respective semantic correlation is performed offline or online  
10 to calculate unigram and bigram frequencies from relevance feedback information,  
11 the unigram frequency being based on relevance feedback to a session of the  
12 multiple search sessions, the unigram frequency indicating that each respective  
13 image of the images is either semantically relevant to the session, semantically  
14 less relevant to the session, or a non-feedback image with respect to the session;  
15 and

16 wherein each respective bigram frequency is based on a pair of unigram  
17 frequencies.

18  
19 48. (Original) A computing device as recited in claim 43, wherein the  
20 processing means for estimating the respective semantic correlation further  
21 comprises means for:

22 associating a respective unigram frequency with each of the images, the  
23 unigram frequency indicating that each respective image of the images is either  
24 semantically relevant, semantically less relevant, or a non-feedback image, the  
25

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1 unigram frequency being based on relevance feedback to a session of the multiple  
2 search sessions; and

3 wherein each respective bigram frequency is based on a pair of unigram  
4 frequencies.

5  
6 49. (Original) A computing device as recited in claim 43, wherein the  
7 processing means for estimating the respective semantic correlation further  
8 comprises means for:

9 associating a respective unigram frequency with each of the images, the  
10 unigram frequency indicating that each respective image of the images is either  
11 semantically relevant, semantically less relevant, or a non-feedback image, the  
12 unigram frequency being based on relevance feedback to a session of the multiple  
13 search sessions;

14 determining a maximum frequency from a maximum value of the bigram  
15 and unigram frequencies; and

16 wherein the respective semantic correlation is further based on the  
17 maximum frequency.

18  
19 50. (Original) A computing device as recited in claim 43, further comprising  
20 processing means for identifying, for each image obtained responsive to one or  
21 more search sessions of the multiple search sessions, a respective semantic support  
22 based on a similarity measure and/or the respective semantic correlation, the  
23 similarity measure corresponding to a similarity of a respective feature vector of  
24 the image and a search query corresponding to the session.  
25



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1 51. (Original) A computing device as recited in claim 43, further comprising  
2 processing means for:

3 identifying, for each image obtained responsive to one or more search  
4 sessions of the multiple search sessions, a respective semantic support based on a  
5 similarity measure and/or the respective semantic correlation, the similarity  
6 measure corresponding to a similarity of a respective feature vector of the image  
7 and a search query corresponding to the session;

8 assigning a respective ranking score to each of the images based upon the  
9 respective similarity measure, the respective semantic support, and a semantic  
10 weight; and

11 displaying only those images with a highest range of respective ranking  
12 scores.

13  
14 52. (Original) A computing device as recited in claim 43, wherein the  
15 processing means for estimating the respective semantic correlation is determined  
16 as follows:

- 17 •  $0 \leq R(I, J) \leq 1$ ;
- 18 •  $R(I, J) = R(J, I)$ ;
- 19 • if  $I=J$  and  $U(I) \leq 0$  :  $R(I, J) = 0$  ;
- 20 • if  $I \neq J$  and  $B(I, J) \leq 0$  :  $R(I, J) = 0$  ;
- 21 • if  $I=J$  and  $U(I) > 0$  :  $R(I, J) = U(I)/T$  ; or
- 22 • if  $I \neq J$  and  $B(I, J) > 0$  :  $R(I, J) = B(I, J)/T$  ;

23 wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency,  $U(I)$  is the  
24 unigram frequency of image  $I$ ,  $T$  is the maximum frequency,  $R(I, J)$  is the  
25 correlation between image  $I$  and  $J$ .

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1  
2 53. (Original) A computing device as recited in claim 43, wherein each  
3 respective bigram frequency is based on a pair of unigram frequencies, and  
4 wherein the processing means further comprise means for performing the  
5 respective semantic correlation offline by:

- 6 (a) initializing all unigram and bigram frequencies to zero;  
7 (b) clustering search sessions with a same query into groups;  
8 (c) calculating unigram counts within a group;  
9 (d) updating unigram frequencies ;  
10 (e) updating bigram frequencies;  
11 (f) repeating operations (c), (d), and (e) for all session groups;  
12 (g) setting all negative unigram and bigram frequencies to zero; and  
13 (h) calculating each respective semantic correlation based on results of (a)  
14 through (f).  
15

16 54. (Original) A computing device as recited in claim 43, wherein each  
17 respective bigram frequency is based on a pair of unigram frequencies, wherein  
18  $C(I)$  is a unigram count of image  $I$ , and wherein the processing means further  
19 comprise means for performing the respective semantic correlation offline by:

20 (a) initializing  $C(I)$  to zero (0);

21 (b) iteratively updating  $C(I)$  for every session in a group such that:

22  $C(I) = C(I) + 1$ , if image  $I$  is labeled as relevant in a session;

23  $C(I) = C(I) - 1$ , if image  $I$  is labeled as irrelevant in a session;  
24

25 and

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$C(I)$  is unchanged otherwise;

(c) repeating (b) for every image of the images;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + \min\{C(I), C(J)\}$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - \min\{C(I), -C(J)\}$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - \min\{-C(I), C(J)\}$ , if  $C(I) < 0, C(J) > 0$ , and

$B(I, J) = B(I, J)$ , otherwise; and

wherein  $I, J$  are two images,  $B(I, J)$  is their bigram frequency, and  $U(I)$  is the unigram frequency of image  $I$ .

55. (Original) A computing device as recited in claim 43, wherein each respective bigram frequency is based on a pair of unigram frequencies, and wherein the processing means further comprise means for performing the respective semantic correlation online by:

(a) calculating unigram counts in a particular search session;

(b) updating unigram frequencies;

(c) updating bigram frequencies; and

(d) updating each respective semantic correlation between each of the images based on results of (a) through (c).

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56. (Original) A computing device as recited in claim 43, wherein each respective bigram frequency is based on a pair of unigram frequencies, wherein  $C(I)$  is a unigram count of image  $I$ , wherein  $U(I)$  is a unigram frequency of image  $I$ , wherein  $B(I, J)$  is a bigram frequency of image  $I$  and  $J$ , wherein a session group comprises a single search session, and wherein the processing means further comprise means for performing the respective semantic correlation online by:

(a) responsive to determining that there is a user log, updating calculating each respective unigram and bigram frequency according to data in the user log;

(b) responsive to determining that there is not a user log, initializing each  $C(I)$  and  $B(I, J)$  to zero (0);

(c) iteratively updating  $C(I)$  for the single search session such that:

$C(I) = 1$ , if image  $I$  is labeled as relevant;

$C(I) = -1$ , if image  $I$  is labeled as irrelevant; and

$C(I) = 0$ , if  $C(I)$  is a non-feedback image;

(d) updating each respective unigram frequencies as  $U(I) = U(I) + C(I)$ ;

(e) updating each respective bigram frequency of an image pair such that:

$B(I, J) = B(I, J) + 1$ , if  $C(I) > 0, C(J) > 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) > 0, C(J) < 0$ ,

$B(I, J) = B(I, J) - 1$ , if  $C(I) < 0, C(J) > 0$ , or

$B(I, J) = B(I, J)$ , otherwise; and

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1 wherein  $I, J$  are two images, and  $B(I, J)$  is their bigram frequency.

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